

Transport, Chemistry, and Energetics of Water in the Mesosphere and Lower Thermosphere and Implications for Polar Mesospheric Cloud Occurrence

Completed Technology Project (2016 - 2019)



Project Introduction

The overall goal of this proposal is to study the time-dependent neutral chemistry and transport of water in the Mesosphere and Lower Thermosphere (MLT) and to determine the resultant impact on the local temperature and ice cloud formation. To reach this goal, we will answer three science questions: 1. What is the energetic and chemical response of the upper mesosphere and lower thermosphere to water deposited in the lower thermosphere? 2. How does the injection of large amounts of water vapor change the thermodynamics and impact the physics of PMC formation? 3. How is the water vapor that gets injected into the lower thermosphere, redistributed vertically to the PMC region near 82 km? To answer these questions we propose to release a plume of water vapor at high latitudes from a rocket payload and observe how the atmosphere responds both during and after the release. We will observe the evolution of the plume of water with lidar measurements from Poker Flat Research Range (PFRR). The lidar is capable of tracking both the optical emissions from the region and measuring the temperature profiles. In addition, an Advanced Mesospheric Temperature Mapper (AMTM) instrument will be deployed at PFRR to observe the upper mesosphere (~87 km) before and during the water release to provide quantitative information on any dynamics/wave activity and changes in mesospheric temperature. The combination of the lidar and mapping imager thus provides strong ground-based diagnostics for the launch. The launch will be at twilight so that any formation of PMCs from the plume will be visible from the ground. Trimethyl aluminum (TMA) trails will be released in addition to the water from a separate payload canister. The TMA is chemi-luminescent and can be tracked optically from the ground with cameras and the naked eye. The movement of the TMA trails will thus provide a direct indication of how the water is moving since both will be transported by the background winds. The TMA measurements will be helpful both for real-time waater cloud tracking and for post-flight analysis. Our ground-based observations will be supported by observations from the NASA TIMED and AIM missions and modeling result from the Thermosphere-Ionosphere-Mesosphere Energetics General Circulation Model (TIMEGCM). We will interpret the observations of PMCs and temperature variations from the TIMED satellite that are driven by the plume chemistry with our TIMEGCM model. The TIMEGCM will be augmented to include all heating and cooling contributions from the plume water vapor, any resultant ice formation as well as vertical transport and heating of the ambient atmosphere by the ice. Model results will be compared with observed PMC data from AIM and corresponding TIMED/SABER temperatures to elucidate and understand the relationship between PMCs and bulk thermodynamics. Perceived significance: The proposed project deals with a science investigation that can be carried out with instruments flown on suborbital sounding rockets. It contributes to the science goal of "understanding the fundamental physical processes of the space environment" (2010 Science Plan for NASA SMD). The proposal is also relevant to the NASA Heliophysics Roadmap, including two out



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Table of Contents

Project Introduction	1
Anticipated Benefits	2
Primary U.S. Work Locations and Key Partners	2
Organizational Responsibility	2
Project Management	2
Technology Maturity (TRL)	3
Technology Areas	3
Target Destination	3

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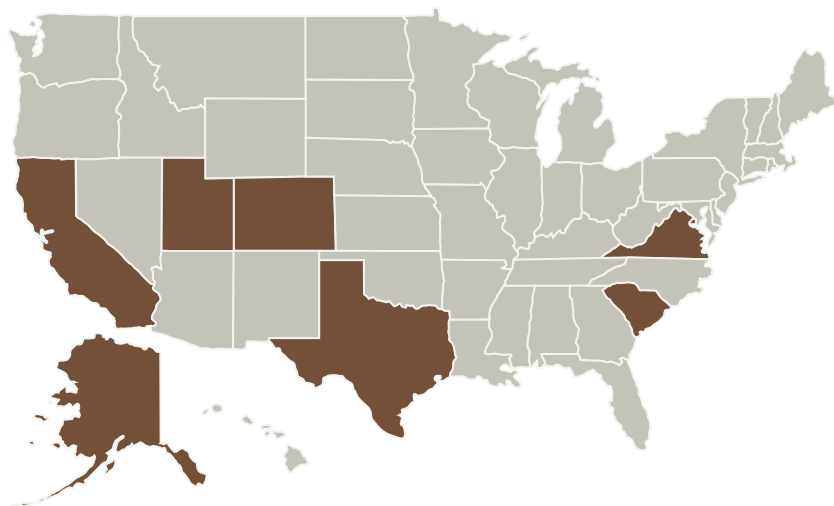
of three overarching objectives: (Open the Frontiers to Space Environment Prediction, and Understand the Nature of our Home in Space) and their associated Research Focus Areas. It also complements work performed under the NASA AIM and TIMED missions.

Anticipated Benefits

Support NASA's strategic objectives to understand the Sun and its interactions with Earth and the solar system, including space weather. This will be achieved by developing/demonstrating instrumentation technology necessary to address the following science goals:

- Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system;
- Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system;
- Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Atmospheric & Space Technology Research Associates, LLC (ASTRA)

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

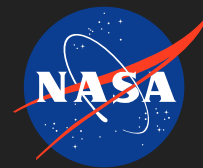
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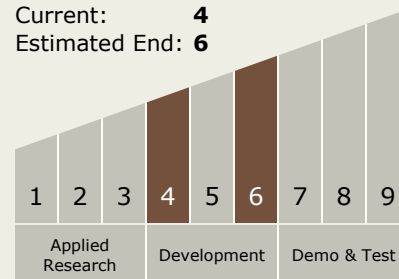


Organizations Performing Work	Role	Type	Location
Atmospheric & Space Technology Research Associates, LLC(ASTRA)	Lead Organization	Industry	Louisville, Colorado

Primary U.S. Work Locations	
Alaska	California
Colorado	District of Columbia
South Carolina	Texas
Utah	Virginia

Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **6**



Technology Areas

Primary:

- TX08 Sensors and Instruments
 - TX08.1 Remote Sensing Instruments/Sensors
 - TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destination

The Sun